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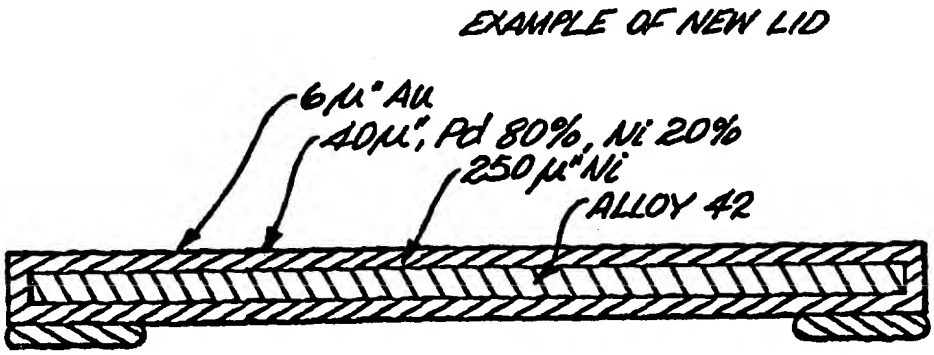
(57) Abstract

A solderable metallic cover for hermetically sealing a ceramic package that includes an iron or iron-alloy core and layers of nickel or nickel alloy on the core and palladium or palladium alloy on the nickel layer.



METAL COVER FOR CERAMIC PACKAGE AND METHOD OF MAKING SAME

Background of the Invention

This invention relates to a sealing cover which is particularly suitable for sealing ceramic packages for semiconductor devices, and to a method of producing the same.

The use of ceramic packages for semiconductor devices is well-known. Typically, such a package includes a ceramic container to which the cover must be sealed. Sealing covers, also known as "lids," of the type used in connection with containers for semiconductor devices are well known and typically include one or more layers of gold, often of substantial thickness, to aid in corrosion resistance as well as to provide for electrical connection of leads. Such covers are not only expensive, but also introduce a possible health hazard since cyanide solutions are often used in gold plating.

The present invention is directed to a novel sealing cover, and to a method of making same, which avoids or at least substantially reduces the use of gold, thus lowering cost and reducing potential health hazards by eliminating or greatly minimizing gold plating. By eliminating or minimizing use of gold, material and manufacturing costs related to the production of lids for semiconductor packages can be significantly lowered. In accordance with the present invention, a sealing cover is provided which is not only economical because it replaces gold with palladium, but is also of sufficiently high quality to pass standard tests for temperature cycling and thermal shock as well as resistance to corrosion in a salt atmosphere.

Although use of palladium in the manufacture of sealing covers is known, such use has been primarily limited to palladium in the form of palladium-silver paste applied to ceramic lids. This use merely takes advantage of the ability of palladium to fuse to ceramic in paste form. However, even in such uses only small quantities of palladium paste are employed, generally around the perimeter of the cover, and the use of palladium in this manner does not materially reduce or affect the overall manufacturing costs.

Miyoshi, et al. U.S. Patent No. 4,640,436 has suggested the use of a coating of gold, palladium, silver or platinum on a solder ring to assist in diffusion bonding of the solder to the lid. In this case, the lid is plated with "a material of high solderability" such as gold. In Levine U.S. Patent Nos. 4,835,067 and 4,666,796, it is suggested to use palladium as a solderable coating on a metal lid as two distinct layers of palladium with a layer of a more reactive metal sandwiched between the two palladium layers. Patentee provides this structure to cancel the galvanic effect that the noble top layer would normally have on the iron-based substrate to which the layers are applied to avoid a possible "short circuit" created if the iron and gold become connected through pinholes in an intermediate layer.

The present invention differs from the prior art, and in particular the disclosures in

Detailed Description of the Invention

In the sealing cover construction described in FIG. 1, the final layer consists of a substantially thick layer of gold. If it is possible to reduce the thickness of the gold coating or eliminate it altogether, while retaining the required characteristics of corrosionresistance, etc. a significant reduction in manufacturing costs would occur. This is accomplished by the cover described in FIG. 2, which is an example of the invention wherein a metallic core is coated with a nickel-containing material, but a palladium-containing layer is applied onto the nickel layer. The use of palladium or a palladium alloy in this manner avoids the need for a thick outer layer of gold and, for many applications, allows the gold layer to be omitted altogether. The term "palladium alloy" as used herein refers to an alloy in which palladium is a major constituent and present in an amount of at least about 30 wt.%.

In accordance with the presently preferred embodiment of the invention, a suitable metallic core, such as one made of iron-nickel alloy, known as "Alloy 42," "Alloy 45" or "Alloy 46" or the alloy known 88 "Kovar," may be provided. Alloys 42, 45 and 46 refer to compositions containing 42, 45 and 46 wt.% nickel, respectively. The particular composition of the core is not critical to the success of the cover of the invention and any iron-based alloy may be used for this purpose provided similar thermal expansion characteristics to ceramic is maintained.

A first layer of nickel or nickel alloy is applied to the core. The nickel-containing material may be applied as an electrolytic or "electroless" coating. Presently, an electrolytic nickel-containing coating is preferred, because it appears to provide good corrosion resistance and economical and repeatable manufacture process. In lieu of a nickel or nickel alloy, a first layer of tin, silver, cadmium, indium, lead, copper, cobalt, ruthenium, iridium, zinc, or their alloys, may be employed. However, it has been determined that nickel and nickel alloys are preferred for their combination of cost, relative ease of application and resistance to corrosion.

The thickness of the first layer is very important in producing a sealing cover with desirable properties. It has been determined that the thickness of the nickel/nickel-alloy layer should be in the range of 100 to 800 μin. Although performance characteristics equal to that obtained with present technology can be achieved with as little as 100 μin, a cover with superior properties is not achieved until the minimum thickness of the nickel/nickel-alloy layer is in the range of 400 to 600 μin. The nominal thickness of this layer is advantageously about 500 μin.

As a second layer, it is important to use a layer of palladium or palladium alloy (as defined previously), and in particular, a palladium-nickel alloy. The most preferred composition presently is an alloy of about 80% palladium and about 20% nickel; however, alloys of at least about 30 wt.% palladium, balance nickel, silver or tin, are also particularly advantageous. In lieu of palladium and palladium alloys as aforesaid, however, it may be

Table 1.

TABLE I

Sample I.D.	Metallization	Thickness
A1	Matte Sulfamate Nickel	(250 μin) Pure Gold(50 μin)
A2	Matte Sulfamate Nickel	(250 μin)
	Palladium/Nickel	(50 μin)
A3	Matte Sulfamate Nickel	(250 μin)
	Palladium/Nickel	(50 μin)
	Pure Gold	(7 μin)
A4	Matte Sulfamate Nickel	(250 μin)
	Tin/Zinc	(100 μin)
B1	Electroless Nickel	(250 μin)
	Pure Gold	(50 μin)
B2	Electroless Nickel	(250 μin)
	Palladium/Nickel	(50 μin)
B3	Electroless Nickel	(250 μin)
	Palladium/Nickel	(50 μin)
	Pure Gold	(7 μin)
B4	Electroless Nickel	(250 μin)
	Tin/Zinc	(100 μin)
C1	Electroless Nickel	(150 μin)
	Matte Sulfamate Nickel	(100 μin)
	Pure Gold	(50 μin)
C2	Electroless Nickel	(150 μin)
	Matte Sulfamate Nickel	(100 μin)
	Palladium/Nickel	(50 μin)
C3	Electroless Nickel	(150 μin)
	Matte Sulfamate Nickel	(100 μ1μ)
	Palladium/Nickel	(50 μin)
	Pure Gold	(7 μin)
C4	Electroless Nickel	(150 μin)
	Matte Sulfamate Nickel	(100 μin)
	Tin/Zinc	(100 μin)
D1	Semi-bright Sulfamate Ni	(125 μin)
	Matte Sulfamate Nickel	(125 μin)
	Pure Gold	(50 μin)
D2	Semi-bright Sulfamate Ni	(125 μin)
	Matt Sulfamate Nickel	(125 μin)
	Palladium/Nickel	(50 μin)
D3	Semi-bright Sulfamate Ni	(125 μin)
	Matte Sulfamate Nickel	(125 μin)
	Palladium/Nickel	(50 μin)
	Pure Gold	(7 μin)
D4	Semi-bright Sulfamate Ni	(125 μin)
	Matte Sulfamate Nickel	(125 μin)
	Tin/Zn	(100 μin)
E1	Palladium/Nickel	(10 μin)
	Matte Sulfamate Nickel	(240 μin)
	Pure Gold	(50 μin)
E2	Palladium/Nickel	(10 μin)
	Matte Sulfamate Nickel	(140 μin)
	Palladium Nickel 80/20	(30 μin)
E3	Palladium/Nickel	(10 μin)
	Matte Sulfamate Nickel	(140 μin)

	Solution temperature	150°F
	Current	Cathodic at 4 volts
	Exposure time	10 minutes
Step 2	D.I. WATER RINSE	
	Exposure time	10 minutes
Step 3	ACID ACTIVATOR	
	Hydrochloric acid	30% by volume
	Solution temperature	Ambient
	Exposure time	10 minutes
Step 4	D.I. WATER RINSE	
	Exposure time	2 minutes
Step 5	*Alternate A* ELECTROLYTIC NICKEL	
	Product	Matte sulfamate nickel
	Nickel concentration	0.5 lbs/gal
	Nickel bromide	2.0 oz/gal
	Boric acid	4.0 oz/gal
	pH	4.3
	Solution temperature	130°F
	Current	12 amperes
	Deposition Rate	90 μin/hour
Step 5	*Alternate B* MID-PHOS ELECTROLESS NICKEL	
	Product	Mid-Phos electroless nickel
	Nickel concentration	0.5 lbs/gal
	pH	5.0
	Solution temperature	150°F
	Deposition Rate	350 μin/hour
Step 6	D.I. WATER RINSE	
	Exposure time	2 minutes
Step 7	ACID ACTIVATOR	
	Hydrochloric acid	30% by volume
	Solution temperature	Ambient
	Exposure time	10 minutes
Step 8	D.I. WATER RINSE	
	Exposure time	1 minute
Step 9	PALLADIUM/NICKEL ALLOY	
	Product	80% Pd - 20% Ni

relatively low melting-point solders are additionally preferred so as to avoid the necessity of exposing the semiconductor device within the package to elevated temperatures, such as might possibly injure the semiconductor. Solder compositions include solders containing in wt.% about 75% tin, about 20% silver and about 5% antimony; solders containing about 84.5% lead, 5.5% indium, 5% tin, 3% antimony and 2% silver; and solders containing up to about 95% lead, preferably not less than 90% lead, up to about 5% palladium and which may additionally include up to about 5% silver, up to about 5% bismuth, up to about 5% antimony, and up to about 5% gold or a mixture of gold and tin having up to about 5% gold and up to about 2% tin. Other useful solders include 95% Pb-5% Pt.

Preferred solder compositions include Pb + Pd (Pd = 2-10 wt.%) and Pb + Pt (Pt = 2-10 wt%), with the following additional elements:

Ag = 0-30 wt.%

Au, Sb, Bi, In, Sn = 0-10 wt.%,

in solders with a melting point of about 220-310°C. Such solders exhibit controlled wet/flow characteristics when reflowed on the covers described herein and demonstrate good visual quality and reliability of sealed packages. Examples of preferred solder compositions include Pb + 4.75% Pd + 5% Ag; and Pb + 5% Pd + 15% Ag.

To further illustrate solders useful in accordance with the present invention, 12 solder compositions shown in the following table have been prepared:

extrusion pressure = 2000-3000PSI, extrusion rate = 20-100IPM.

Strip roll

Preheat 350-450F for 30 minutes, rough roll at 350-450F with reduction of over 0.020" to thickness of 0.010", finish roll at 200-300F with reduction of 0.001-0.004" to thickness of 0.002-0.005", rolling lubricant = 4-B oil or Hexane.

Strip clean

Methylene chloride bath clean followed by inert gas bagging to prevent oxidation of the pb solder.

Perform punch

Die punch into specified preforms.

Preform clean

Methylene chloride bath clean followed by inert gas bagging to prevent oxidation of the pb solder.

Preform tack weld to cover

Tack weld the preform to the cover (made from a conductive substrate and plated with a solderable surface layer) to form a preform/cover assembly.

Package cover/preform assembly

Put the preform/cover assemblies into appropriate plastic packages and fill the package with an inert gas to prevent Pb solder oxidation during shipping and storage.

Method B, Continuous cast

Alloy and continuous slab cast

Make appropriate alloy and form a continuous cast slab of about 0.200" thick and 2.500" wide under inert gas protection with cooling water to reduce the alloy segregation and obtain fine crystal structure.

Strip roll

Same procedure as in Method A.

Strip clean

alloy and 5 μin Au results in < 0.5% surface area corrosion and an average of about 0.1%.

The following is an example of one preferred embodiment. A core of "Alloy 42" is spot welded to a solder ring, i,e., preform. Three steps are used to fabricate a complete lid.

A. Plated lid production.

B. Solder ring production and punching.

C. Attachment of the solder ring to the plated lid.

Each process is described in detail below.

A. Plated Lid Production

Alloy 42 (Fe 58%, Ni 42%) is rolled into sheets 0.010" to 0.015" thick, and annealed into a state making it suitable for punching (typically 95,000 psi tensile strength). The sheet is slit into coils wide enough to make them easily punched through a progressive die set.

Using standard technology this material is then punched into sizes suitable for sealing onto ceramic packages. Typical sizes include:

.250"	x	.375"	x	0.010"
.505"	x	.505"	x	0.010"
.860"	x	.860"	x	0.015"

The punched squares may then be deburred chemically or mechanically to clean up any rough edges that may result from metal shearing.

The cleaned and deburred lids may than be loaded into a plating barrel for degreasing, oxide removal, and electroplating of all desired layers. One barrel of low cost lids were plated using the following sequence:

1. A Sterling System 6" x 12" plating barrel was loaded about 30% full with .605" x .605" x 0.010" alloy 42 squares which had been previously punched and deburred in the manner described above.

2. This barrel was plated with nickel, palladiumnickel and gold using the following sequence:

   a. Electroclean at 5 volts anodic for 5 minutes;
   b. Rinse for at least 5 minutes;
   c. Descale in acid blend for 5 minutes;
   d. Rinse for 2 minutes;
   e. Plate in Sulfamate Nickel for ample time to deposit 500 μin;
   f. Rinse for 5 minutes;
   g. Acid activate in 5% HCl (optional);
   h. Plate in Pd-Ni for ample time to deposit 40 μin;
   i. Rinse for 5 minutes;
   j. Plate in a high adhesion pure gold bath for ample time to deposit 5 μin

WHAT IS CLAIMED IS:

1. A solderable metallic cover for hermetically sealing a package containing a semiconductor device comprising a core of iron or iron-nickel alloy, a first layer on said core comprising nickel, tin, silver, cadmium, indium, lead, copper, cobalt, ruthenium, iridium, zinc, and alloys thereof, and a second layer on said first layer comprising palladium, tin, platinum, silver, cadmium, indium, cobalt, lead, rhodium, ruthenium, iridium, and alloys thereof, and a layer of gold on said second layer of a thickness of 0 to 50 μin.

2. A cover according to claim 1 wherein said first layer comprises one from the group consisting of electrolytic and electroless nickel and alloys of nickel of a thickness of 100 to 800 μin.

3. A cover according to claim 2 wherein said first layer is 400 to 600 μin.

4. A cover according to claim 1 wherein said second layer comprises 20 to 60 μin.

5. A method of assembling a semiconductor device package comprising soldering a cover according to claim 1 to a ceramic enclosure having a semiconductor device therein to hermetically seal said package with a gold-free solder selected from the group consisting of solders containing at least one of Pb, Sn, Ag, In, Bi, Pd, Pt and Sb, and which has a melting point in the range of from about 220°C to 300°C.

6. A method according to claim 5 wherein said solder comprises in wt.% about 75% Sn, about 20% Ag and about 5% Sb.

7. A method according to claim 5 wherein said solder comprises in wt.% about 84.5% Pb, about 5.5% In, about 5% Sn, about 3% Sb and about 2% Ag.

8. A method according to claim 5 wherein said solder comprises about 95% Pb and about 5% Pd.

9. A method according to claim 5 wherein said solder comprises up to about 95% Pb, up to about 5% Pd, up to about 5% Ag, up to about 5% Bi, up to about 5% Sb, up to 5% AU, and up to 7% of a mixture of Au and Sn having up to about 5% Au and up to 2% Sn.

17. A soldered, hermetically sealed semiconductor package comprising a ceramic enclosure having a semiconductor device therein and a cover soldered to the ceramic enclosure to hermetically seal said ceramic enclosure, said cover including a core comprising an iron or iron-nickel alloy, a first layer on said substrate comprising nickel, tin, silver, cadmium, indium, lead, copper, cobalt, ruthenium, iridium, zinc, and alloys thereof, a second layer on said first layer comprising palladium, tin, platinum, silver, cadmium, indium, cobalt, lead, rhodium, ruthenium, iridium, and alloys thereof, said cover being soldered to said ceramic enclosure with a gold-free solder selected from the group consisting of solders containing at least one of Pb, Sn, Ab, In, Bi, Pd, Pt and Sb, and which has a melting point in the range of from about 220°C to 300°C.

18. A sealing cover consisting essentially of an iron and nickel alloy core, a 400 μin thick first layer of material from the group consisting of nickel, tin, silver, cadmium, indium, lead, copper, cobalt, ruthenium, iridium, zinc, and alloys thereof, a 20-60 μin second layer of a material from the group consisting of palladium, tin, platinum, silver, cadmium, indium, cobalt, lead, rhodium, ruthenium, iridium, and alloys thereof and a layer of 0 to 15 μin of gold on the second layer.

19. A sealing cover consisting essentially of an iron and nickel alloy core, a 400 μin thick first layer of material from the group consisting of nickel and nickel alloys, a 20-60 μin second layer of a material from the group consisting of palladium and palladium-nickel alloys and a layer of 0 to 15 μin of gold on the second layer.

20. A method of making a sealing cover comprising providing a core of an alloy of iron and nickel, applying a first layer to the core comprising nickel or nickel alloy of 100 to 800 μin thickness and applying a second layer onto the first layer of palladium or palladium-nickel alloy of 10 to 100 μin thickness.

21. A method according to claim 19 further comprising applying a layer of gold of 0 to 15 μin thickness onto the second layer.

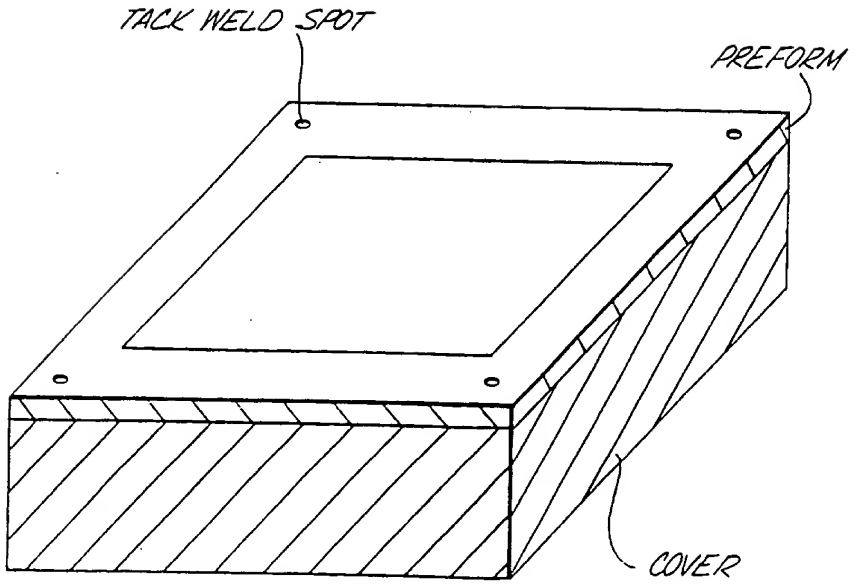
22. A method according to claim 19 wherein said first layer is applied as a layer of 400 to 600 μin thickness.

23. A method according to claim 19 wherein said second layer is applied as a layer of 20 to 60 μin thickness.

24. A method according to claim 19 wherein said first layer is electrolytic nickel.

34. An assembly according to claim 26 wherein said solder comprises up to about 10% Pd and up to about 30% Ag.

Fig. 3



INTERNATIONAL SEARCH REPORT

International application No.
PCT/US95/09124

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US,A,4,640,436 (MIYOSHI ET AL.) 03 FEBRUARY 1987, FIGS.1-3	1-34
Y	US,A,4,601,958 (LEVINE) 22 JULY 1986, ENTIRE DOCUMENT	1-34
Y	US,A,4,331,253 (GORDON ET AL.) 25 MAY 1982, COL.3, LINES 1-49	1-34
Y	US,A,4,331,258 (GESCHWIND) 25 MAY 1982, ENTIRE DOCUMENT	1-34
Y	US,A,4,141,029 (DROMSKY) 20 FEBRUARY 1979, FIG.3	1-34
Y	JP,A, 63-5550 (YAMAWAKI) 11 JANUARY 1988, SEE CONSTITUTION	5-15,17,26-34